REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ADDRESS.

1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED *(From - To)*

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)	8. PERFORMING ORGANIZATION REPORT NUMBER
Department of the Air Force Headquarters Pacific Air Forces, CHECO Division Hickam AFB, HI	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT

A -- Approved for Public Release

13. SUPPLEMENTARY NOTES

14. ABSTRACT

Project CHECO was established in 1962 to document and analyze air operations in Southeast Asia. Over the years the meaning of the acronym changed several times to reflect the escalation of operations: Current Historical Evaluation of Counterinsurgency Operations, Contemporary Historical Evaluation of Combat Operations and Contemporary Historical Examination of Current Operations. Project CHECO and other U. S. Air Force Historical study programs provided the Air Force with timely and lasting corporate insights into operational, conceptual and doctrinal lessons from the war in SEA.

15. SUBJECT TERMS

CHECO reports, Vietnam War, War in Southeast Asia, Vietnam War- Aerial Operations, American

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			19b. TELEPHONE NUMBER *(Include area code)*

[redacted]

PROJECT CHECO SOUTHEAST ASIA REPORT

PAVE AEGIS WEAPON SYSTEM (AC-130E GUNSHIP)

(THIS PAGE IS UNCLASSIFIED)

[redacted]

SECRET

PROJECT
Contemporary
Historical
Examination of
Current
Operations
REPORT

PAVE AEGIS WEAPON SYSTEM (AC-130E GUNSHIP)

30 JULY 1973

HQ PACAF

Directorate of Operations Analysis
CHECO/CORONA HARVEST DIVISION

SPECIAL HANDLING REQUIRED
NOT RELEASABLE TO
FOREIGN NATIONALS

The information contained in this document will not be disclosed to foreign nationals or their representatives.

Prepared by:
LT COL TILL
MAJ THOMAS

Project CHECO 7th AF, CDC

SECRET

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS PACIFIC AIR FORCES
APO SAN FRANCISCO 96553

PROJECT CHECO REPORTS

The counterinsurgency and unconventional warfare environment of Southeast Asia has resulted in the employment of USAF airpower to meet a multitude of requirements. The varied applications of airpower have involved the full spectrum of USAF aerospace vehicles, support equipment, and manpower. As a result, there has been an accumulation of operational data and experiences that, as a priority, must be collected, documented, and analyzed as to current and future impact upon USAF policies, concepts, and doctrine.

Fortunately, the value of collecting and documenting our SEA experiences was recognized at an early date. In 1962, Hq USAF directed CINCPACAF to establish an activity that would be primarily responsive to Air Staff requirements and direction, and would provide timely and analytical studies of USAF combat operations in SEA.

Project CHECO, an acronym for Contemporary Historical Examination of Current Operations, was established to meet this Air Staff requirement. Managed by Hq PACAF, with elements at Hq 7AF and 7/13AF, Project CHECO provides a scholarly, "on-going" historical examination, documentation, and reporting on USAF policies, concepts, and doctrine in PACOM. This CHECO report is part of the overall documentation and examination which is being accomplished. It is an authentic source for an assessment of the effectiveness of USAF airpower in PACOM when used in proper context. The reader must view the study in relation to the events and circumstances at the time of its preparation--recognizing that it was prepared on a contemporary basis which restricted perspective and that the author's research was limited to records available within his local headquarters area.

Robert E. Hiller

ROBERT E. HILLER
Director of Operations Analysis
DCS/Operations

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS PACIFIC AIR FORCES
APO SAN FRANCISCO 96553

REPLY TO ATTN OF: DOAD

30 July 1973

SUBJECT: Project CHECO Report, "PAVE AEGIS Weapon System (AC-130E Gunship)"

TO: SEE DISTRIBUTION PAGE

1. Attached is a SECRET document. It shall be transported, stored, safeguarded, and accounted for in accordance with applicable security directives. Retain or destroy in accordance with AFR 205-1. Do not return.

2. This report supercedes the earlier, 16 February 1973 CHECO report on the same subject. Destroy the 16 February edition in accordance with AFR 205-1.

3. This letter does not contain classified information and may be declassified if attachment is removed from it.

FOR THE COMMANDER IN CHIEF

V. H. Gallacher

V. H. GALLACHER, Lt Colonel, USAF
Chief, CHECO/CORONA HARVEST Division
Directorate of Operations Analysis
DCS/Operations

1 Attachment
(S) Project CHECO Report,
30 July 1973

DISTRIBUTION LIST

1. SECRETARY OF THE AIR FORCE
   - a. SAFAA 1
   - b. SAFLL 1
   - c. SAFOI 2
   - d. SAFUS 1

2. HEADQUARTERS USAF
   - a. AFNB 1
   - b. AFCCS
     - (1) AFCCN 1
     - (2) AFCVC 1
     - (3) AFCHOS 2
   - c. AFCSA
     - (1) AF/SAG 1
     - (2) AF/SAMI 1
   - d. AFIGO
     - (1) AFOSI/IVOA . . 3
     - (2) IGS 1
   - e. AFIS/INTC 5
   - f. AFACMI 1
   - g. AFODC
     - (1) AFPRC 1
     - (2) AFPRE 1
     - (3) AFPRM 1
   - h. AFPDC
     - (1) AFDPW 1
   - i. AFRD
     - (1) AFRDP 1
     - (2) AFRDQ 1
     - (3) AFRDQPC 1
     - (4) AFRDR 1
     - (5) AFRDQL 1
   - j. AFSDC
     - (1) AFLGX 1
     - (2) AFLGF 1
     - (3) AFLGT 1
     - (4) AFLGY 1
   - k. AFXO 1
     - (1) AFXOD 1
     - (2) AFXODC 1
     - (3) AFXODD 1
     - (4) AFXODL 1
     - (5) AFXOOG 1
     - (6) AFXOSL 1
     - (7) AFXOOSN 1
     - (8) AFXOOSO 1
     - (9) AFXOOSS 1
     - (10) AFXOOSV 1
     - (11) AFXOOSR 1
     - (12) AFXOOSW 1
     - (13) AFXOOSZ 1
     - (14) AFXOXAA 6
     - (15) AFXOXXG 1

3. MAJOR COMMAND

a. TAC

(1) HEADQUARTERS
- (a) XPSY 1
- (b) DOC 1
- (c) DREA 1
- (d) IN 1

(2) AIR FORCES
- (a) 12AF
  - 1. DOO 1
  - 2. IN 1
- (b) 19AF (IN) 1
- (c) USAFSOF(DO) . . . 1

(3) WINGS
- (a) 1SOW(DOI) 1
- (b) 23TFW(DOI) 1
- (c) 27TRW(DOI) 1
- (d) 33TFW(DOI) 1
- (e) 35TFW(DOI) 1
- (f) 366TFW(DOI) . . . 1
- (g) 67TRW(DOI) 1
- (h) 316TAW(DOX) . . . 1
- (i) 317TFW(DOI) . . . 1
- (j) 474TFW(DOI) . . . 1
- (k) 463TAW(DOX) . . . 1
- (l) 58TAC FTR TNG WG . 1
- (m) 354TFW(DOI) . . . 1
- (n) 314TAW(DOI) . . . 1
- (o) 4410SOTG(DOI) . . 1

(4) TAC CENTERS, SCHOOLS
- (a) USAFTAWC (IN). . . 1
- (b) USAFTFWC (DR). . . 1
- (c) USAFAGOS (EDA) . . 1

b. SAC

(1) HEADQUARTERS
- (a) XPX 1
- (b) LG 1
- (c) IN 1
- (d) NR 1
- (e) HO 1

(2) AIR FORCES
- (a) 2AF(IN) 1
- (b) 8AF(DOA). 2
- (c) 15AF(INCE) . . . 1

c. MAC

(1) HEADQUARTERS
- (a) DOI 1
- (b) DOO 1
- (c) CSEH 1
- (d) MACOA 1
- (e) 60MAWG (DOI) . . 1

(2) MAC SERVICES
- (a) ARRS(XP) 1

d. ADC

(1) HEADQUARTERS
- (a) DO 1
- (b) DOT 1
- (c) XPC 1

(2) AIR DIVISIONS
- (a) 25AD(DOI) 1
- (b) 20AD(DOI) 1

e. ATC

(1) DOSPI 1

f. AFSC
(1) HEADQUARTERS
(a) XRP 1
(b) SDA 1
(c) HO 1
(d) ASD(RWST) 1
(e) RADC(DOT) 1
(f) ADTC(CCN) 1
(g) ADTC(DLOSL) . . . 1
(h) ESD(YWA) 1
(i) AFATL(DL) 1
(j) ESD(XRL) 1

g. USAFSS
(1) HEADQUARTERS
(a) AFSCC(SUR) 2

h. USAFSOS
(1) HEADQUARTERS
(a) EDS 1

i. PACAF
(1) HEADQUARTERS
(a) DP 1
(b) IN 1
(c) XP 2
(d) CSH 1
(e) DC 1
(f) LG 1
(g) DOAD 6

(2) AIR FORCES
(a) 5AF
1. CSH 1
2. XP 1
3. DO 1
(b) 13AF(CSH). . . . 1
(c) 7AF/OLAA(CHECO). 2

(3) AIR DIVISIONS
(a) 313AD(DOI) . . . 1
(b) 314AD(XP) . . . 1
(c) 327AD(IN) . . . 1

(4) WINGS
- (a) 8TFW(DON) 1
- (b) 56SOW(WHD). 1
- (c) 6280CSG(DO) 1
- (d) 388TFW(DO) 1
- (e) 405TFW(DOI) 1
- (f) 432TRW(DOI) 1
- (g) 1st Test Sq(DA) . . . 1

j. USAFE

(1) HEADQUARTERS
- (a) DOA 1
- (b) DOLO 1
- (c) DOOW 1
- (d) XP 1

(2) AIR FORCES
- (a) 3AF(DO) 1
- (b) 16AF(DO) 1

(3) WINGS
- (a) 50TFW(DOA) 1
- (b) 20TFW(DOI) 1
- (c) 401TFW(DCOI) 1
- (d) 513TAW(DOI) 1

4. SEPARATE OPERATING AGENCIES

a. DMAAC/PR. 1

b. AFRES(XP) 2

c. 3825 Acad Svs Gp
- 1. ACSC-DAA . . . 1
- 2. AUL/LSE-69-108 2
- 3. HOA 2

d. ANALYTIC SVS, INC.1

e. AFAG(THAILAND). . 1

5. MILITARY DEPARTMENTS, UNIFIED AND SPECIFIED COMMANDS, AND JOINT STAFFS

a.	COMUSJAPAN/J3	1
b.	CINCPAC (J301)	2
c.	CINCPACFLT (Code 332)	1
d.	COMUSKOREA (ATTN: J-3)	1
e.	COMUSMACTHAI/MACTJ3	1
f.	COMUSTDC (J3)	1
g.	USCINCEUR (ECJB)	1
h.	CINCLANT (CL)	1
i.	CHIEF, NAVAL OPERATIONS	1
j.	COMMANDANT, MARINE CORPS (ABQ)	1
k.	CINCONAD (COOP)	1
l.	DEPARTMENT OF THE ARMY (ASM-D)	1
m.	JOINT CHIEFS OF STAFF (J3RR&A)	1
n.	JSTPS	1
o.	SECRETARY OF DEFENSE (OASD/SA)	1
p.	CINCSTRIKE (STS)	1
q.	CINCAL (J2)	1
r.	MAAG-CHINA (MGOT-LA)	1
s.	U.S. DOCUMENTS OFFICE, HQ ALLIED FORCES NORTHERN EUROPE	1

6. SCHOOLS

a.	Senior USAF Representative, National War College	1
b.	Senior USAF Representative, Armed Forces Staff College	1
c.	Senior USAF Rep, Industrial College of the Armed Forces	1
d.	Senior USAF Representative, Naval Amphibious School	1
e.	Senior USAF Rep, U.S. Marine Corps Education Center	1
f.	Senior USAF Representative, U.S. Naval War College	1
g.	Senior USAF Representative, U.S. Army War College	1
h.	Senior USAF Rep, U.S. Army C&G Staff College	1
i.	Senior USAF Representative, U.S. Army Infantry School	1
j.	Senior USAF Rep, USA JFK Cen for Mil Asst	1
k.	Senior USAF Representative, U.S. Army Field Artillery School	1
l.	Senior USAF Representative, U.S. Liaison Office	1
m.	Senior USAF Rep, U.S. Army Armor School, Comd and Staff Dept	1

7. SPECIAL

a.	The RAND Corporation	1

TABLE OF CONTENTS

LIST OF FIGURES

FOREWORD

Conceived in 1970, the PAVE AEGIS system went from concept to combat in little more than a year. The explosive power of the 105mm howitzer and the accuracy of the digital computer combined to make the AC-130E PAVE AEGIS equipped gunship a truly awesome weapon system. This report discusses the authorization, initial test, and combat employment of the system.

Much of the data concerning the PAVE AEGIS project was obtained from the files of 7AF, 7/13AF, and the 16SOS, Ubon RTAFB. Additionally, interviews granted by the Commander, crew members, and support personnel of the 16th Special Operations Squadron were of great help. Without their assistance it would have been extremely difficult to relate the significant aspects of the PAVE AEGIS system to the operational environment in Southeast Asia (SEA).

[redacted]

CHAPTER I

SYNOPSIS OF THE USAF GUNSHIP PROGRAM

General Curtis E. LeMay, Air Force Chief of Staff, gave the go-ahead for the gunship program in 1964.[1/] This decision--to use the antiquated C-47 gooney bird as a close air support aircraft (FC-47)--has had far-reaching ramifications. Over the years the success of this innovation in combat led to the introduction of other aircraft into the program and the steady development of increasingly sophisticated and powerful weapon systems.

The prototype of USAF fixed-wing gunships, the FC-47, armed with 7.62mm guns (capable of firing 6,000 rounds per minute) and flares (usually manually dispensed), first saw action in the fall of 1964 and had proven itself in combat by 1965. Shortly thereafter the USAF changed the aircraft designation to the AC-47 and assigned it the operational call sign "Spooky."

Target acquisition presented major problems to early gunship crews. Electronic navigation equipment was very basic: radios, TACAN, vectors from ground radar and forward air controllers (FACs) assisted Spooky to the target area.* After acquiring the target, the pilot, aiming through a gunsight mounted on the left cabin window, began a 30 degree bank flying a pylon turn. He made the necessary corrections during the firing

---

*Once there, the target had to be acquired visually without the assistance of the special sensors that later were trademarks of gunship operation.

[redacted]

orbit, increasing or decreasing the range of the fixed guns by adjusting the bank angle and rate of turn of the aircraft. The accuracy of the firepower at this time directly related to the pilot's skill.

Initially assigned the role of supporting hamlets and outposts under night attack, Spooky aircraft soon came to be used for local base defense, airborne alert, air cover for Medevac flights, convoy escorts, and interdiction. Because of an extended time on target (TOT) capability, Spooky also acted as a forward observer for artillery and provided battlefield information to friendly ground forces.[2/]

As time went on, the need for a gunship capable of using larger weapons and employing a better fire control system led to the introduction of the C-130A during the fall of 1967. Heralding a new era in gunship development, this prototype was armed with four 20mm vulcan gatling gun cannons and four 7.62 miniguns. The installation of three sensors--a night observation device (NOD), an infrared (IR) sensor and a beacon tracking radar (BTR)--greatly reduced target acquisition problems. A second major advancement was an improved fire control system (FCS). An analog computer calculated and developed for the pilot a moving reticle which he then superimposed on a fixed reticle representing the gun's position in reference to the target. Additionally, the computer gave the pilot the information necessary to enter the firing orbit smoothly. With its increased firepower and electronic equipment the AC-130 proved to be the most effective aircraft for night interdiction in SEA, surpassing even its role of close air support.[3/]

The Air Force, however, realized in 1968 that large numbers of C-130s could not be modified for gunship duty without seriously degrading the airlift mission. At this point the USAF modified the C-119G flying box car and deployed it to SEA in December 1968. The AC-119G "Shadow" was armed with four 7.62mm miniguns, contained a computerized FCS, a night observation sight, an illuminator, and a flare launcher. The Shadows, too, were extremely effective in providing close air support (CAS) for troops in contact (TIC), convoy escort and armed reconnaissance.[4/]

One year later the AC-119K "Stinger" entered the gunship inventory. Similar in many respects to the Shadow, the Stinger additionally contained two 20mm cannons, a BTR, and an infrared sensor, which expanded its capability and made it effective both as a truck killer and for providing close air support for troops in contact. While not having all the advantages of the AC-130, the Shadow and Stinger nevertheless performed admirably in a variety of roles.[5/]

Concurrently with the employment of the AC-119K, an AC-130A (nicknamed "Surprise Package") reached SEA. It contained 13 major subsystem additions or modifications not found in the AC-130A prototype.[6/] The "Surprise Package" aircraft obtained outstanding results during the Commando Hunt III Campaign, damaging or destroying (d/d) 822 trucks, or nearly 7.5 trucks per sortie. Before the Commando Hunt III Campaign was over the "Surprise Package" and the other AC-130s accounted for 3,414 trucks, or 34 percent of all trucks d/d, while flying only 4-1/2 percent of the sorties.[7/]

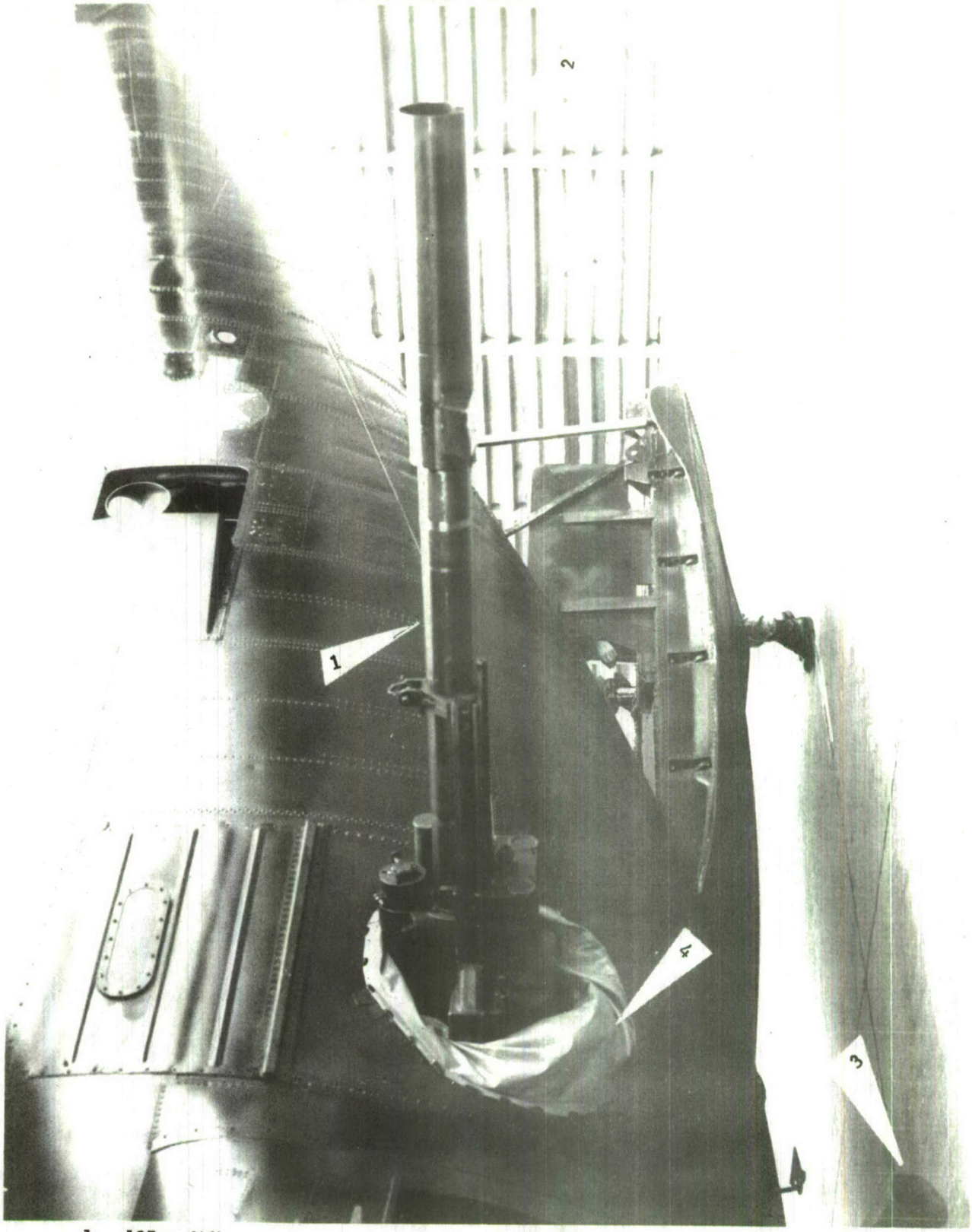
From the summer of 1970 through early 1971, additional modifications were made to the AC-130A fleet. Heavier armament, in the form of two 40mm Bofor cannons, was combined with two 20mm Vulcans and two 7.62 miniguns. Then in the fall of 1971, the AC-130E "Spectre"* gunship with very sophisticated equipment made its debut into the USAF inventory, and AC-130 subsystems were once again modified and updated. A more advanced fire control system, using a digital computer, was installed together with additional electronic gear.[8] Also, the fuel capacity was enlarged, and the Spectres proved ideal for supporting ground actions in distant target areas. The Spectres were used extensively and with good results in the truck killing role during the Commando Hunt VII campaign.[9]

GUNSHIP ARMAMENT[10]

Gunship	Size of Gun System	Rate of Fire
AC-47 AC-119G AC-130	7.62mm (Minigun)	Fast: 6,000 rds/min or Slow: 3,000 rds/min
AC-119K AC-130	Added 20mm (Gatling)	2,500 rds/min
AC-130A (Surprise Package)	Added 40mm (BOFORS)	Single round or 120 rds/min (muzzle velocity 2870 fps)
AC-130E (PAVE AEGIS)	Added 105mm (Howitzer)	Single round or 3 rds/min (muzzle velocity 1600 fps)

*All AC-130E aircraft were called "PAVE SPECTRE." AC-130A aircraft were called "PAVE PRONTO." The word "SPECTRE" applies to any AC-130 gunship.

Since its inception, the gunship program has been highly successful. Each modification has incorporated a variety of changes designed for more efficient mission accomplishment. As the enemy threat has increased, the gunship technology and tactics have kept pace, always aimed at improving the aircraft and crew survivability while improving the accuracy and firepower of the weapons system. The latest innovation in gunship technology, PAVE AEGIS, is the subject of this report.



1. 105mm GUN
2. BLAST DEFLECTOR FOR 105mm
3. BLAST DEFLECTOR FOR 40mm
4. Flexible CANVAS BAFFLE

SIDE VIEW OF THE PAVE AEGIS 105mm GUN

FIGURE 1

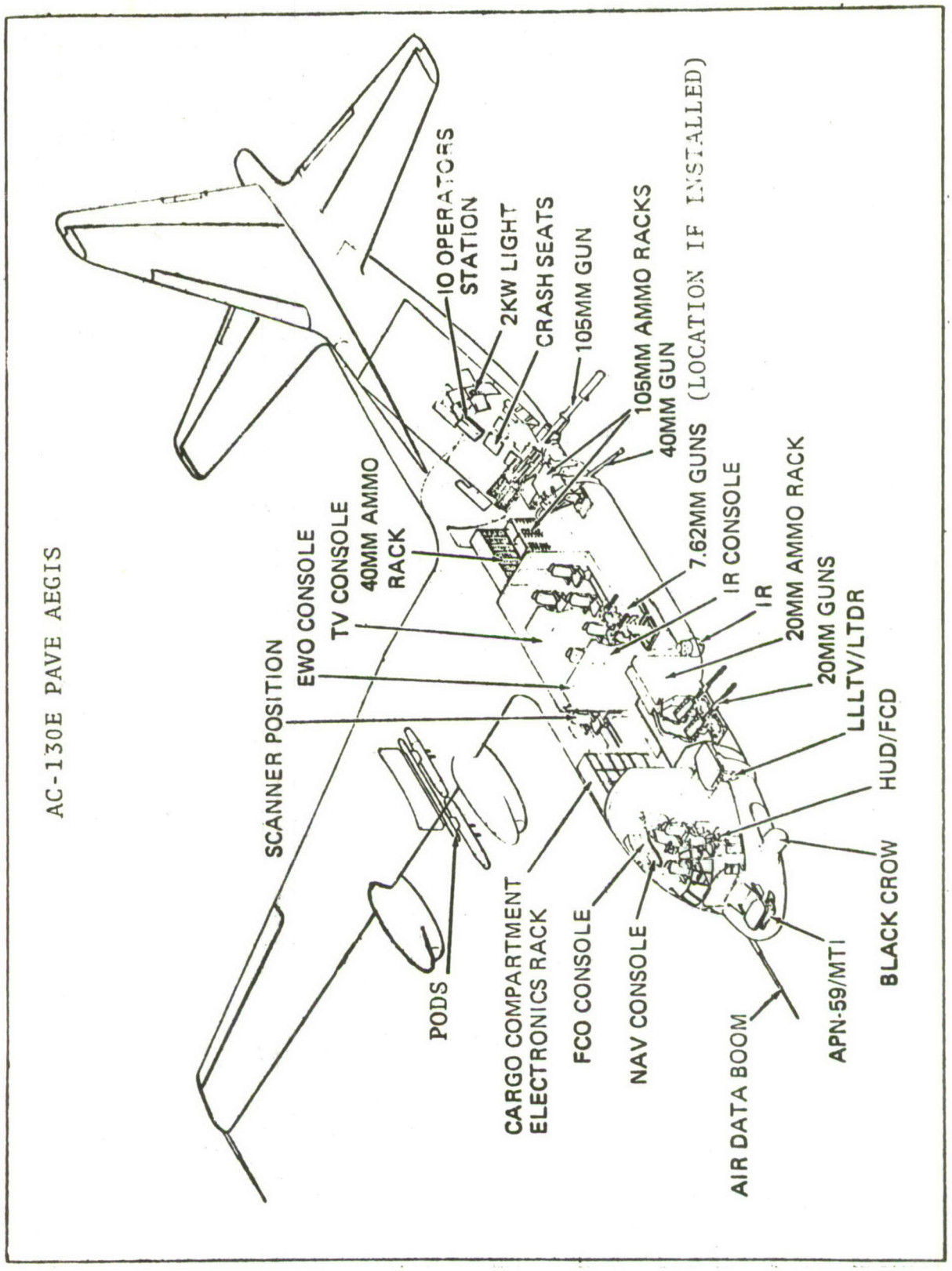

AC-130E PAVE AEGIS
SCANNER POSITION
EWO CONSOLE
TV CONSOLE
40MM AMMO RACK
10 OPERATORS STATION
2KW LIGHT
CRASH SEATS
105MM GUN
105MM AMMO RACKS
40MM GUN
(LOCATION IF INSTALLED)
7.62MM GUNS
IR CONSOLE
IR
20MM AMMO RACK
20MM GUNS
LLLTV/LTDR
HUD/FCD
BLACK CROW
APN-59/MTI
AIR DATA BOOM
NAV CONSOLE
FCO CONSOLE
CARGO COMPARTMENT ELECTRONICS RACK
PODS

FIGURE 2

CHAPTER II

PAVE AEGIS PROGRAMS, OBJECTIVES AND CONUS TESTING

In early 1971, Headquarters USAF approved the PAVE AEGIS development program to determine the feasibility of firing a large-caliber weapon from the AC-130A gunship.[11/] Although the USAF considered several weapons from the 75mm to the 105mm howitzer, the 105mm was selected for test because of its longer range, greater explosive power, and the variety of ammunition available.[12/]

From 11 through 17 September 1971, crews from the 4950 Test Wing (Tech) flew six test sorties to obtain data for evaluation. Test objectives were to confirm the feasibility of mating the 105mm gun with the AC-130 airframe and to confirm the structural integrity of the aircraft by actual in-flight firing.[13/] All firing was done at 8,000 feet above ground level at 150-160 knots indicated air speed from a normal gunship orbit with the gun at a preset fixed position. Ordnance of varying charges was expended in each test to provide adequate strain gauge data. Initial results revealed that the gun did not affect the plane's handling characteristics and that stress analysis compared favorably with predicted results.[14/]

In the PAVE AEGIS Program Plan, it was noted that the AC-130E would be used instead of the "A" model due to its greater gross weight capability and the better accuracy of its digital fire control system. It was also recommended that, if possible, a combat evaluation be conducted during

the forthcoming Commando Hunt VII Campaign.* [15/] This generated considerable concern within PACAF, Seventh Air Force, and the 8th Tactical Fighter Wing (TFS); because of their mission in SEA, they did not want to divert assets with proven capabilities to test unproven concepts.**

Aeronautical Systems Division (ASD) of AFSC proceeded on the assumption (not universally shared by the commands involved) that the planned 105mm gun installation had been fully agreed upon. Meanwhile, on 4 November, CINCPACAF asked Seventh Air Force for its view on the 105mm deployment (with an in-theater installation) during the current "hunting" season. On 10 November, CINCPACAF commented that the PAVE AEGIS system could be installed on the sixth AC-130E aircraft, which was scheduled to arrive in SEA in late December 1971 following completion of CONUS modifications. Seventh Air Force (DO) replied that they had insufficient information on which to base a reply and asked CINCPACAF for additional details.[16/] That same day, CINCPACAF sent ASD a message to the effect that "informal information" indicated that "a 105mm cannon has been installed and tested on an AC-130 test bed," and requested ASD to clarify PAVE AEGIS advantages. CINCPACAF relayed the information to Seventh Air Force and asked whether they would be interested in employing the 105mm system if advantages were as stated.[17/] Still another message that same day from CINCPACAF to CSAF

---

*COMMANDO HUNT: Air interdiction campaigns to impede the overland flow of supplies from NVN, Laos and Cambodia. Each campaign bore a numerical designation that corresponded with the annual monsoon seasons, i.e., I, III, V, VII, roughly October through April, were dry season operations.

**See p. 12.

stated that CONUS installation of the 105mm would significantly delay delivery of the new "E" models to SEAsia, and suggested that in-theater modification should be feasible with about one day's effort. PACAF informed ASD that the "timely arrival of gunships is imperative," and once again queried Seventh Air Force for comments on field installation and late delivery.[18] Nine days later, following field inputs, CINCPACAF sent a lengthy message to ASD posing very specific questions about capabilities, training, ballistics, accuracy, ammunition safety, and the major advantages of the system.[19]

While ASD was staffing this message, the Secretary of the Air Force was briefed on the AC-130E PAVE AEGIS proposal at the monthly meeting of the Program Assessment Review Board. On 19 November the Chief of Staff approved the program, directing that testing be expedited with subsequent deployment to SEA by February 72 if the tests proved satisfactory.[20] This would permit combat evaluation of the AC-130E PAVE AEGIS during the Commando Hunt dry season. By 22 November, AFSC had been notified of this decision and in turn tasked ASD to submit a formal plan for the PAVE AEGIS program. ASD promptly designated the Gunship Project Office (SDY) as the primary management office.[21]

On 24 November, AFSC provided positive answers to all of CINCPACAF's questions of the 19th, and added that they (AFSC) had been authorized to make the 105mm available for deployment and in-theater installation in February 1972.[22]

On 1 December, a planning conference convened at Wright-Patterson AFB to develop a plan for the PAVE AEGIS system. The plan developed by the conferees was in two phases. Phase I was scheduled for Hurlburt Field, Florida, in mid-January, 1972. The testers were to install the gun, verify its compatibility with the AC-130E, determine that field installation in SEA was feasible, and verify by actual firings the ballistics and accuracy of the 105mm gun and the digital fire control system. Phase II was to encompass the installation and combat deployment of the 105mm gun in an AC-130E Spectre at Ubon RTAFB, Thailand. The conference ended on 2 December, and the program plan was promptly sent to the field.[23/]

As late as 10 December, Seventh Air Force was still very much concerned that the proposed modification was going to have an adverse effect on existing mission capability, and reiterated to CINCPACAF that "diversion of Seventh Air Force operational AC-130E assets for the purpose of testing during the current dry season [is] unacceptable." Seventh Air Force went on to request that the TAC aircraft to be modified and used in the test should be deployed to SEA for a 30 day combat evaluation.[24/] TAC opposed this proposal on the grounds that their resources would be diluted by such a deployment, and suggested the entire program be dropped. Once again, the CSAF intervened, stating on 14 December that he and the Secretary of the Air Force felt the advantages of flexibility, survivability, and effectiveness required a "go ahead" and that PACAF resources would be used in SEA.[25/]

Seventh Air Force made one last unsuccessful appeal to CINCPACAF on 20 December:[26]

> We suspect that the Phase 1 CONUS test objectives cannot be adequately investigated in the short time allocated. We are concerned that if a system is deployed prematurely, loss of a prime 7AF gunship will occur during the height of the truck killing season and in-theater resources will be required to correct the deficiencies. In addition there is certain to be some degradation during the initial installation of equipment and training of personnel. In summary we feel that the decision to deploy the PAVE AEGIS to SEA on 1 Feb 72 should be held in abeyance until such time as PACAF/7AF are assured that the system has completed development, been thoroughly tested in the CONUS, deficiencies corrected and the system offers an improved capability over that which we now possess.

Nevertheless, the PAVE AEGIS program had developed too much high level interest to be turned back now. PACAF had been represented at the PAVE AEGIS conference and had agreed upon the test objectives and the time frame.[27] It now became a matter of waiting for the actual evaluation.

The modification began at Hurlburt Field on 17 January 1972 with the installation of the 105mm gun. The results of the earlier AC-130A tests were used to improve the design and installation. A test crew of personnel from the 415 Special Operations Training Squadron and ASD flew 15 missions under simulated combat conditions. Ten of the missions were considered productive: all test objectives were met and all systems performed as well as or better than expected. The 105mm was determined to

be definitely compatible with the AC-130E airframe. Team members estimated that it would take only 13-15 hours to remove, install, align, and boresight the equipment. Flights at high and low altitudes with various slant ranges verified the tentative ballistics tables. The accuracy of the 105mm gun with the Fire Control System surpassed the predicted results.

An extensive evaluation of high explosive (HE) and white phosphorus (WP)* 105mm ammunition against vehicles, bunkers and anti-aircraft guns showed that the HE round was more effective against all types of targets than the WP; however, the WP was considered excellent for daytime target marking, and good even at night. A super-quick fuze setting was recommended for both types of ammunition.[28/]

Following the successful tests, Phase II of the PAVE AEGIS plan was ready for implementation. As with all major gunship modifications, however, certain changes had to be made to enable the AC-130E currently in SEA to accept the 105mm howitzer.

---

*Termed "Willie Peter" or "Willie Pete" by aircrews.

CHAPTER III

THE PAVE AEGIS WEAPON SYSTEM

The entire PAVE AEGIS 105mm gun assembly included a modified M-102 weapon, blast diffuser, recoil assembly and snubber assembly, mount, adapter base plate, ammunition storage and handling system, safety cage, and a modified 40mm ammunition rack. The rest of the systems used in conjunction with the PAVE AEGIS were already present on the AC-130E aircraft. These consisted of sensors, other guns, illuminators, and ECM equipment. Specific 105mm ballistics data were programmed into the digital computer. A 28 volt DC signal initiated the firing and was the only electrical interface between the gun and the computer.[29] A complete list of all major systems and subsystems is contained in Appendix 1.

To install the 105mm weapon, the aft 40mm gun and APQ-150 Beacon Tracking Radar were removed to make room for the new 105mm gun, two 105mm ammunition racks, and a modified 40mm ammo rack. The Beacon Tracking Radar was programmed for relocation in subsequent AC-130Es. The palletized 105mm gun assembly recoil mechanism and adapter plate were installed in the left paratroop door where the APQ-150 Radar had been. The muzzle was equipped with a three-foot blast deflector to prevent blast damage to the left wing area. A canvas baffle, secured to the gun and the aircraft, reduced the amount of air flowing through the plane during flight. When in the firing position, the 105mm gun had a greater traverse and depression capability than the 40mm. From a reference line straight out the left

paratroop door, the azimuth angle was 0 to 20 degrees aft, and the elevation angle was 0 to -40 degrees.

Several safety features were incorporated in the PAVE AEGIS system. An open wire mesh cage was mounted behind the gun carriage to protect the crewmembers from the vicious 45- to 52-inch recoil. As with the 40mm guns, the 105mm was connected to a gun safe/arm control box.

The downward depression of the gun barrel required that each 105mm shell be crimped before delivery to the aircraft. Crimping secured the semi-fixed projectile to the shell, thus preventing possible spillage of the propellant charge when loading. Crimping also permitted the removal of the faulty round in case of a misfire, without leaving a flammable residue.

Special emphasis was placed on the handling of the 31-inch, 42-pound 105mm rounds. Engineers designed two storage cabinets to hold the shells; one cabinet just forward of the right paratroop door contained 72 rounds, while a 24-round cabinet occupied the position left vacant by the removal of the 40mm gun. Each round was separately latched into a drawer containing four rounds. This drawer was then held shut--or open if in use--by a latch designed to prevent the rounds from coming loose during sudden evasive maneuvers.

The modification added 4,750 pounds to the gross weight of the airplane. The 105mm gun and assorted equipment and ammo weighed over 7,300

pounds, but the removal of the 40mm gun, 300 rounds of ammo and the APQ-150 BTR offset that weight by 2,550 pounds. It was originally estimated that the increase would only be about 2,000 pounds.

While the entire modification appeared quite extensive, it was estimated that in-theater installation could be accomplished in 12-15 hours. This was highly desirable, since installation would not interfere with normal gunship scheduling.[30/]

CHAPTER IV

COMBAT EMPLOYMENT OF PAVE AEGIS

The PAVE AEGIS AC-130E was assigned to the 16th Special Operations Squadron (SOS), 8th Tactical Fighter Wing (TFW), Ubon RTAFB, Thailand. On 18 February 1972, the first 105mm gun was installed and two training missions were conducted on 22 and 23 February.[31/]

The first mission, in northern Cambodia, provided the crew with a variety of experience. Numerous equipment problems were encountered and several shells misfired. Moreover, additional training missions were needed to fully acquaint the crew with the new interior and to develop necessary coordination. Pilots had to refine control techniques to meet the new calibration procedures. Gunners had to become thoroughly familiar with the new weapons and also learn how to maneuver safely in a dimly lit cargo compartment while handling the 42-pound shells. The crew felt, nevertheless, that it was just a matter of time before they could successfully operate in a hostile environment.[32/]

The second training mission, flown the following night, went extremely well. The permissive environment allowed the select 8 TFW/ASD crew to become thoroughly familiar with the various systems and the new gun, and with only minor exceptions all systems worked as expected.

The first combat mission was flown the next night, 24 February 1972, in an armed reconnaissance role in support of the Commando Hunt VII campaign.

Although the three firing and sensor tracking systems did not function perfectly, the aircraft commander, Captain Weylon Fulk, reported that of 12 trucks attacked, 12 were destroyed or damaged. The 105mm howitzer accounted for three destroyed and four damaged trucks while the 40mm guns were credited for the rest.[33/] This was a harbinger of things to come.

As soon as it appeared that the PAVE AEGIS was a success, ASD reminded PACAF that a second 105mm gun and additional parts were available for installation at Ubon. The following day, 3 March, Seventh Air Force relayed this information to the 8 TFW, noting that there were sufficient parts and spares available to support the operation of one PAVE AEGIS aircraft for six to nine months or two aircraft for three months.[34/] Shortly thereafter Seventh Air Force concurred with a PACAF recommendation that the aircraft be operated for 10-14 days before a decision was made, and still later, on 13 March, Seventh Air Force recommended that "the installation of the second PAVE AEGIS be held in abeyance pending completion of system safety analysis."[35/] At this point, combat action partially decided the question. On the night of 15 March the PAVE AEGIS aircraft suffered moderate structural damage when hit by 57mm AAA fire. Fortunately there were no injuries and the gun was not damaged. By the next day the 105mm had been removed, installed in another aircraft, and was again ready for combat.[36/]

On 16 March, 8 TFW sent a message to Seventh Air Force saying that the primary advantage of the 105 thus far was its single round destructive

effect and cited mission 5200 on 4 March when a single projectile destroyed three collocated trucks. The message went on to state that although there was no clear evidence that the 105mm had done more damage than the two 40mm would have done under similar conditions, they recommended "the selection of the two 105mm gun installation option,"[37] i.e., two PAVE AEGIS equipped aircraft for three months. Seventh Air Force was also impressed. That same day, in a reply to a request from 7/13th Air Force and OUSAIRA VTN, Laos, concerning an anticipated tank attack, Seventh Air Force said:[38]

> . . . the 105mm gun equipped AC-130 will arrive shortly after 2000G. Would appreciate notification to ground FAGs that this tremendously effective weapon will be available . . .

And admiration continued to grow as a message from 8 TFW to Seventh Air Force on 29 March proclaimed:[39]

> PAVE AEGIS has produced results as advertised for the 8 TFW. Destructive power, accuracy and reliability have been most impressive.

CINCPACAF had now apparently decided that both PAVE AEGIS systems should be used and asked the Air Force Inspection and Safety Center for a waiver of the system safety analysis on the second gun.

Impressive results continued, and by 30 March 32 PAVE AEGIS sorties had been flown by the one PAVE AEGIS aircraft. The crews had observed 239 trucks, attacked 229, and d/d 218 with a combination of the 40mm and 105mm guns. The 105mm howitzer was credited with 76 percent of the 218 trucks damaged or destroyed.[40]

Before the second aircraft could be configured, however, the existing PAVE AEGIS aircraft (aircraft 571) was downed by enemy AAA on the night of 30 March.[41] Another Spectre gunship from the 16 SOS was instrumental in the SAR. Through the use of extremely sensitive sensors, it was possible actually to "see" the downed personnel on the ground and assist them in finding adequate protective cover. The entire crew was recovered safely the following day.[42] Quickly, the remaining 105mm gun was installed in aircraft 570 and flown on 31 March. It remained the only one until 1 May 1972 when another system arrived and was installed.

In April 1972, the NVA/VC launched a major offensive in South Vietnam and PAVE AEGIS played a key role in halting the invasion. All available gunships did yeoman service in support of the beleaguered troops, but the PAVE AEGIS was particularly effective since with the proper ammunition it had the firepower to destroy a tank. To capitalize on this capability, attempts were made to supplement the 105mm HE round with 105mm high explosive anti-tank (HEAT) ammunition, but it was unavailable. This round had not been tried during the CONUS testing of the AC-130E due to safety and availability problems.[43] Against tanks, the next most suitable (and readily available) ordnance was the M327 high explosive plastic (HEP) round, either traced or untraced, but the Non-Nuclear Munitions Safety Group had not validated this round for use in PAVE AEGIS nor had Seventh Air Force granted the final safety certification for continuous firing.[44] However, on 26 May Seventh Air Force approved a test of 30 rounds of traced M327 HEP to determine the ballistics parameters to be set into the PAVE

AEGIS FCS. The round was acceptable but the tracer elements revealed the aircraft's position. Consequently, as a result of both the absence of validation of the ordnance and the special problems attending the use of tracer rounds, Seventh Air Force directed that the M327 HEP round be used only in a tactical emergency and then only upon direction of 7AF/DO.[45/]

Even without the most appropriate tank-killing ordnance, the PAVE AEGIS destroyed or damaged an impressive number of tanks during the invasion. On 15 April five tanks were destroyed with fewer than 10 rounds.[46/] On the night of 23 April the PAVE AEGIS system destroyed or damaged five tanks in the Kontum area.[47/] Captain Fulk noted that "prior to the PAVE AEGIS, the 40mm round would destroy or damage a tank only if the crew scored a lucky shot."[48/] With the greater amount of explosive in the 105mm projectile, the tank had a much larger vulnerable area.

The PAVE AEGIS system had to earn its reputation during the North Vietnamese invasion. Initially the Forward Air Controllers (FACs) were unaware of the 105mm howitzer capabilities and frequently held the gunship off target while other aircraft expended. In one instance, a PAVE AEGIS aircraft was held off target so an F-4E could make 20mm strafing runs. Often the gunship was moved off target so that TACAIR could expend and, on occasion, TACAIR so saturated the area that the PAVE AEGIS aircraft could not even get targets assigned.[49/] Still, it did not take the ground commanders long to recognize the punch of the PAVE AEGIS system, and it

quickly became routine to ask each arriving AC-130 Spectre, "Do you have the Big Gun?"* [50/] The reputation grew despite the fact that only one plane in the entire gunship fleet was PAVE AEGIS equipped until 1 May 1972.

One commander, call sign "Tunnel 10A," quickly exploited the 105mm capabilities. When told a PAVE AEGIS was arriving he announced: "Great! I've been waiting 24 hours for you to get here and hit this target. O.K. All you other guys move off. 'Big Bertha' is here." [51/]

Other ground commanders directed PAVE AEGIS' firepower toward camouflaged tanks and enemy troop concentrations protected in buildings. During fierce house-to-house fighting at An Loc, one commander took full advantage of the PAVE AEGIS accuracy and firepower, giving the crew corrections in five meter increments. [52/] At one point Spectre crews were provided with hand-drawn city maps of An Loc. [53/] According to Lt Colonel Kelsay, typical instructions might be:

> Go north along main street for three blocks, turn east there, hit the second house from the corner.

As the walls blasted out and the roof tumbled down from the 105mm round impact, the next set of directional instructions followed. Lt Colonel Kelsay pointed out: [54/]

---

*Soon after initial use the 105mm was commonly referred to as the "Big Gun." Pilots coming on target were asked, "Do you have the Big Gun?" 16 SOS personnel have likewise adopted this expression with some affection.

> Valuable time and ammo were saved by this directional method rather than having to make corrections with a coordinated firing pattern.

Army officers at An Loc praised the PAVE AEGIS lavishly. The Senior Army Adviser to the 3rd Ranger Group at An Loc from 8 April to 31 May stated:[55]

> In a building the best ordnance you can put on it is napalm; and a Spectre with a 105 will run anybody out of any place--a Spectre with a 105 is the most devastating weapon they have.

Major K. A. Ingram, USA, who spent 31 days at An Loc, told a Stars and Stripes reporter:[56]

> . . . There was nothing the NVA could do when the . . . [PAVE AEGIS] was overhead except crawl into a hole and hope that it didn't hit them.

During the same interview Captain Harold Moffett, USA, a veteran of 53 days at An Loc was quoted:

> . . . Communist soldiers fled their bunkers when AC-130 . . . [PAVE AEGIS] gunships fired on their positions. . . . The American attack plane was the single most effective weapon used at An Loc.

Close coordination and mutual respect had evolved between gunship crews and ground commanders. On 12 May, during the siege at An Loc, Colonel W. F. Ulmer, USA, the Senior American Adviser to the ARVN 5th Division, recalled how the PAVE AEGIS had assisted in driving the VC-NVA from a narrow salient northeast of An Loc. Only the accurate fire of

the gunship could be used. Claymore mines were placed around the perimeter. The 105 was then used to drive the enemy from the bunkers to be killed by air or by running into the claymore mines.[57/]

An equally successful tactic was tried near Dak Pek on 10 June. The ground situation was becoming critical, the PAVE AEGIS-equipped gunship's Loran was inoperative, weather was 7/8 undercast, and the ground commander had no "X" band beacon. At this point the gunship dropped flares near friendly positions and received ground verification. As the sensors picked up these positions, the fire control officer manually updated his position to the known reference and prepared to fire. A trial run was made to prevent a short-round incident. From that point on, using corrections from the ground commander to adjust their fire, the crew expended 62 rounds of 105mm and 216 rounds of 40mm, all at distances less than 500 meters from friendly troops. The enemy attack was broken and ground action ceased. A later sweep of the area revealed 50 enemy killed by air.[58/] From April through June the PAVE AEGIS system--while installed in only 12-1/2 percent of the fleet--accounted for 55 percent of the tank BDA.[59/] As a result of these and other exploits, the PAVE AEGIS weapon system had amply demonstrated its versatility and effectiveness. (See Appendix 2.)

CHAPTER V

PAVE AEGIS TRAINING AND TACTICS

Even before the PAVE AEGIS Program Plan was developed, PACAF was concerned that additional training would be required for the 105mm gun. This was discussed with ASD, and PACAF was assured that the special training required for 105mm gunners would be accomplished prior to arrival in SEA. Additionally, two gunners from ASD were to be sent to Ubon RTAFB to conduct OJT for other gunners.[60/] The 2 December Program Plan stipulated that special gunnery training would be required, but stated that while no formal aircrew or maintenance training would be established, a special crew would accompany the PAVE AEGIS system to SEA and train the crews.[61/] Still, Seventh Air Force told PACAF that "there is certain to be some operational degradation in the initial installation of equipment and training of personnel."[62/]

It is a credit to the specially selected crew that little or no mission effectiveness was lost during the transition. This crew, trained by the ASD team, in turn checked out other Spectre crews. Two to four special training sorties were usually required to adjust to the demands of the PAVE AEGIS system. Some of this time had to be used just acquainting the crew with the new configuration and teaching them how to handle heavy (42 pound) rounds safely.[63/] The 16 SOS commander indicated that the crew adjusted without difficulty to these new demands.[64/] It was soon discovered that by flying closer to the nominal geometry patterns and reducing

reticle movement rate, the accuracy could be substantially improved. However, with the increased explosive power of the 105mm round, accuracy might have suffered had not the crews stressed the goal of "fewer shots" for effect. Initially, crews felt that too much time was spent setting up to fire the 105mm gun over the target. As a result, the ASD team conducted a rigorous evaluation and found that it took one minute less to destroy or damage a truck with the 105mm gun even using the 40mm battle damage assessment (BDA) criteria.[65/]

Sufficient crews were available by the end of March to employ both PAVE AEGIS systems had installation been possible. Due to early combat losses, however, it was 1 May 1972 before two PAVE AEGIS equipped gunships were simultaneously available.

While initial training was of concern to Seventh Air Force, they were equally concerned over just how to employ the 105mm gun. The initial tests had proved that the gun would work in the AC-130E, but it was almost entirely due to the tactics developed by the resourceful, professional crews that the weapon was so successfully employed in combat. The tactics they developed represented a modification of standard gunship tactics. Essentially, the 20mm guns were used when a "shotgun" firing pattern was appropriate; the 40mm and 105mm were used on point targets.

The first PAVE AEGIS Weekly Activity Report sent to the CSAF began:[66/]

> During initial PAVE AEGIS missions various techniques were being used to determine the best procedures for employing the 40mm and 105mm guns as a complementary system . . .

The initial missions revealed that the 105mm and the 40mm were very compatible and several tactics quickly developed. To obtain a ballistics wind for the FCS, the 40mm gun was fired several times, usually at various points during a normal orbit. Using this information, the 105mm could then be programmed without expending valuable ammunition.

Truck interdiction developed a rather set pattern. A miss up to 35 feet with a 105mm round had sufficient pyrophoric effect to ignite flammables on a truck; however, when the truck did not "blow or burn" a 40mm misch metal projectile was fired to ignite any spilled fuel or oil. On other occasions a 40mm shell was used to stop a truck which was then destroyed by the 105mm gun.[67/]

The 105mm system could be used not only on tanks, as has been pointed out, but also on a variety of "harder" targets such as buildings and bunkers. A 105mm round placed on or near an AAA site could silence it for the night or longer.[68/] This was especially beneficial since the enemy had been expanding his AAA and SAM operating areas ever further to the south. On 15 March the first PAVE AEGIS aircraft sustained heavy damage from 57mm AAA. This caused not only PAVE AEGIS aircraft but all gunships to reevaluate their tactics. PACAF was deeply concerned as the following message to Seventh Air Force indicates.[69/]

> . . . it would seem the time is ripe to determine new ways in our gunship operation to place the enemy on the defensive by having to react to new tactics.

The message proposed removing the 20mm and 40mm guns to allow room for more 105mm ammo since the 105 could operate above the effective 37mm AAA range.

The 8 TFW opposed this proposal in a message to Seventh Air Force. To them, the removal of the 20mm and 40mm guns would effectively negate the operational flexibility which had been developed since the introduction of the 105mm gun:[70/]

> The AC-130E with PAVE AEGIS is a flexible and versatile weapon system capable of operating over a wide range of altitudes and performing a variety of missions. To remove small caliber weapons would restrict operational employment of E model gunships. To rely on AC-130A or AC-119 to support TICs could jeopardize timely response so necessary in such situations.

Seventh Air Force agreed with 8 TFW and sent a carefully worded message to PACAF: "Appreciate your concern and comments" but "we are taking action to improve AAA suppression." The message went on to state several reasons why an increase in altitude would have more disadvantages than advantages--increased opportunity for clouds and haze to obscure the target, reduced sensor target size, and increased impact error.[71/]

PAVE AEGIS crews forced to higher altitudes by the AAA threat were disappointed with the results achieved, due primarily to the sensor

degradation. Crews viewed the enemy AAA barrage as more of a harassment than a constant threat. For example, when a STRELA (SA-7) hit and damaged aircraft 573 on 12 May, the crew estimated that over 400 rounds of AAA had been fired at the craft in the preceding 10 minutes. At night, evasive maneuvers could be taken against AAA without difficulty, but daytime AAA was more difficult to spot and hence to evade.* 72/

All AC-130s were normally forbidden to work in any known missile environment day or night. The prime reason for this was the poor maneuverability of the aircraft at the higher altitudes. It was possible to evade a missile if it was detected in time; nevertheless, the SA-2 posed such a high kill probability that gunships were restricted from both confirmed and probable SA-2 operating areas, and while IRCM flares could be used to decoy the heat-seeking SA-7 Strela missile, 73/ gunships were also restricted from high threat SA-7 areas.

Seventh Air Force, well aware of the different tactics required to effectively combat AAA and missiles, summed up their views of PAVE AEGIS employment. 74/

> Our approach to the problem is to retain maximum tactical flexibility. We allow crews to select higher altitude options as the situation warrants and will reemphasize this point. . . .

The other tactics used by the PAVE AEGIS crews were similar to those used throughout the gunship fleet especially in Spectres.

---

*For a fuller discussion of the enemy threat to USAF gunships, see Project CHECO Southeast Asia Report (S), The Role of Gunships in SEAsia, 30 Aug 69, pp. 35 ff, and Project CHECO Southeast Asia Report (S), Fixed Wing Gunships in SEA, 30 Nov 71, pp. 43 et passim.

CHAPTER VI

EVALUATION OF THE PAVE AEGIS WEAPON SYSTEM

Any attempt to evaluate firing accuracy under combat conditions is subject to certain inherent errors. For example, in many cases results can not be observed, and in others the crew is just too busy staying alive to worry about such details as computed impact points (CIP) and circular error probable (CEP). Still, realistic criteria were developed and a PAVE AEGIS accuracy evaluation was made comparing test and combat results.

The CONUS tests were flown at 8,500 feet or more above ground level, and combat conditions were simulated as much as possible. For example, a new target was selected for each two or three rounds fired and the aircraft bank angle was varied. The accuracy achieved during the tests was much better than predicted. At 8,500 feet and slant ranges of 11,000 to 13,000 feet, the system achieved a 50 percent CEP of one milliradian (mil), i.e., 50 percent of the rounds would be expected to impact within a circle, centered at the target, with radius corresponding to a one milliradian variation of the gun from its aiming point.* The 99 percent CEP was 2-1/2 mils and the 100 percent 6 mils. At 14,500 to 15,500 feet altitude and 18,000 to 22,000 feet slant range, the 50 percent CEP was 2 mils and the 100 percent CEP was 5 mils. The ASD test report predicted, however, that some accuracy degradation was to be expected in actual combat.[75/]

---

*At a 10,000-foot slant range, one mil corresponds to approximately 10 feet on the ground.

The accuracy evaluation in combat compared the computed impact point with the estimated impact point as observed on the primary firing sensor. In order to approximate a "true" representative picture, the PAVE AEGIS combat accuracy figures were smoothed and known errors identified from data collected in the fire control recording system were eliminated. For example, excessive gun misalignment during the boresighting,* results not observed (RNO), and fire control system malfunctions were deleted from the combat data evaluated.

An AFSC liaison officer from the Air Force Academy calculated the PAVE AEGIS combat testing results. Appendix 3 presents the accuracy data of both the CONUS and combat tests. The figures presented seem to be representative of the PAVE AEGIS weapon system's accuracy.[76/] As predicted, the gun under combat conditions was not as accurate as in the CONUS testing. However, one of the scored missions approximated the same Eglin curve shown in Appendix 3. The overall accuracy, 2.4 mils CEP, exceeded the initial PAVE AEGIS accuracy results expected (3 mils).

Part of the success was due to a "coincidence rate gate" control mechanism in the fire control system. The pilot flew the plane to align in his target scope an electronic blip representing the computed impact point with a geometrical figure. When the two display figures were aligned, coincidence was achieved and the CIP was on the target. The 105mm howitzer

---

*Boresighting was a technique used to align the tracking sensors and guns with azimuth and elevation settings in the fire control system. This was a calibration process normally accomplished prior to attacking the first target.

still might not fire, however, due to the aircraft's rate of roll exceeding the allowable value.* If the computer detected that the preset firing parameters had been exceeded, the gun would not fire until they were within bounds. Consequently, pilot error, even though quite small, remained the largest source of error introduced into the fire control system on a continuous basis.[77]

The fire control system was affected at different times by other variables, including poor point targets, periodic ballistic wind changes as well as circular winds in some areas, and to a lesser degree, variations in sensor tracking information. Such unpredictable factors could not be programmed into the computer ballistic equations.[78]

The excellent combat accuracy (2.4 mils) achieved by the 16 SOS resulted from pilot skill, fire control system sophistication, and timely inputs into the computer by crew members. Captain Fulk felt that the tighter flying parameters required were very desirable:[79]

> . . . The crew develops as a much more accurate crew because of the precision that is demanded by the system. After firing PAVE AEGIS, I was a much better "shot" with the 40mm system. . . .

---

*The digital computer parameters to fire the PAVE AEGIS weapon were zero to one milliradian coincidence, near nominal bank angles, and one half degree per second rate gate. The pilot had to fly within these parameters before the gun would fire.

Concerning combat accuracy, the PAVE AEGIS 75-Day Report stated that 13 percent of the 105mm rounds hit the target, 28 percent hit within 1 mil, 44 percent within 2 mils, and 12 percent fell outside 5.4 mils. For a "normally" operating system (no serious fire control system malfunction), combat CEP was about 2.4 mils. That is, at the ranges at which the rounds were fired (about 10,000 feet), 50 percent of the rounds impacted within 25 feet of the center of the target.[80/]

To evaluate overall PAVE AEGIS effectiveness, various factors had to be considered, i.e., availability of targets, TOT, size of target, type of target, and terrain. One method used was to compare the number of trucks attacked with the number of trucks destroyed or damaged. The PAVE AEGIS 75-Day Report showed 298 trucks attacked and 284 d/d, a 96 percent effectiveness rating. Of these 284 trucks d/d, the 105mm gun accounted for 223, or 79 percent, while the 40mm system was credited with the remainder.

Another method used in the evaluation compared the length of time over the target and the BDA per sortie. In terms of length of time over target, the report stated that once a truck was spotted, an average of 7.5 rounds and 13.5 minutes were required to destroy or damage it. The 75-Day Report gave BDA of 6.6 trucks per sortie with the 105mm system accounting for five of these.[81/]

When compared to the 9.72 trucks d/d per sortie during Commando Hunt V just one year earlier, these figures are not as impressive. This points

out the problem of realistic evaluation. The PAVE AEGIS was not deployed until the latter part of the Commando Hunt VII campaign, and by that time the crews felt you "really had to dig them [trucks] out."[82/] Additionally, the enemy had changed his tactics. Trucks no longer traveled in large convoys but, rather, at widely separated and random intervals, and an increased AAA and SAM threat restricted the PAVE AEGIS from certain areas.[83/]

A previous CHECO report indicated that claimed truck BDA had exceeded the intelligence estimates of enemy trucks in the area and yet trucks continued to roll. During the Commando Hunt V campaign, gunship crews reported a direct hit by a 40mm round as a truck destroyed, regardless of whether or not a secondary explosion or fire resulted; a 40mm round impacting just short of the target was reported as a truck damaged. When, at the end of Commando Hunt V, it became apparent that the number of trucks being reported as destroyed was not consistent with the number of trucks known to be in the enemy inventory, crews were directed to revise their criteria: a direct hit by a 40mm round was to be reported as a truck damaged, unless there was an explosion or secondary fire, in which case the truck was to be reported destroyed. The 40mm near miss was deleted as a part of BDA criteria.[84/]

The introduction of the devastating PAVE AEGIS 105mm gun called for a total reevaluation of BDA criteria. It became immediately apparent to the 16 SOS that the 40mm criteria should not be used for the 105mm gun. After all, the 105mm round had nine times more explosive power. On the very first combat mission on 24 February the crew reported that four trucks were hit directly by 105mm rounds but did not explode and therefore the trucks were considered damaged. On the other hand, two of the trucks were reported as destroyed even though they were a "near miss" as each truck suffered a sustained fire.[85/] This indicated a need to establish special BDA criteria for the 105mm round.

On 6 March 1972 the 8 TFW sent a message to Seventh Air Force requesting a reevaluation of the current BDA criteria and proposing new criteria. This message stated, in part:[86/]

> . . . it has become increasingly apparent that the present BDA criteria used for 40 and 20 ordnance is inadequate to quantify assessment of 105mm effectiveness against enemy vehicular traffic . . . the present 40mm criteria results in an "overkill" situation in that near misses are not counted yet obviously damage the vehicle. . . .

In a 7 March message to CINCPACAF, Headquarters USAF concurred in the new BDA criteria, but at the same time qualified their position, stating:[87/]

> This headquarters concurs, however, it is recommended that the damage criteria be, "truck target will be considered damaged if a 105mm round impacts within 20 feet low in relation to the target." The destroy criteria should remain the same, i.e., the truck should blow up or burn to be considered destroyed

> until AFSC/ASD establishes that a single direct hit by a 105mm high explosive (HE) round will destroy a truck.

In an 8 March message to CINCPACAF, ASD stated:[88]

> We concur wholeheartedly that the present BDA criteria used for 40mm and 20mm ordnance is inadequate for effective assessment of the 105mm HE ordnance against truck targets. The present criteria will result in an "overkill" situation and waste of rounds.

The message went on to state that the 20 foot criterion proposed by the 8 TFW was indeed conservative, since Eglin tests revealed that misses of 30 to 35 feet resulted in substantial damage, and recommended that

> . . . any three rounds placed within 20 feet low, forward or aft of the same truck type target will render that target destroyed even without benefit of secondary fires or explosions.

In reference to the Headquarters USAF request concerning the effects of a direct hit, the ASD message said, "We agree that a direct hit on a truck target with no secondary explosion or fire be considered a destroyed target."

It should be recalled that one of the primary benefits envisioned in the PAVE AEGIS program plan was that each 105mm round could put 5.6 pounds of high explosive on the target as compared with 0.6 pounds of HE for the 40mm round.[89] Nevertheless, in a message to Seventh Air Force, CINCPACAF without reference to the 8 March ASD message recommended disapproval of any changes in BDA criteria for the 105mm weapon.[90]

> . . . at present, there is no clear and overriding justification for changing the truck BDA criteria to accommodate the 105mm gun. It should be noted that the tests conducted at Bien Hoa on 12 May 71 demonstrated that near misses with 40mm cause little or no damage to a truck . . . the fact that there is a difference in the 40mm and 105mm effectiveness is appreciated. However, in the interest of accurate and credible BDA reporting it does not appear prudent to alter the existing criteria unless hard evidence shows conclusively that one to two mil misses with the 105mm cause disabling damage. . . . At this point it appears that insufficient evidence exists to warrant proposing a mod [sic] to existing BDA criteria as established by CINCPAC.

Seventh Air Force agreed that the BDA criteria should not be changed, reasoning that [91/]

> . . . a change at this point in the Commando Hunt VII season would only lower confidence in fundamental indicators of command operational effectiveness.

The introduction of a previously-unused weapon system certainly called for a reevaluation of existing BDA criteria. Failure to change the criteria in order to maintain the same data base while changing the inputs is difficult to understand. Once again, the aircrews were attempting to develop meaningful criteria based on actual combat experience.

The disapproval had a direct effect upon the PAVE AEGIS crews, and this fact had been succinctly pointed out in an 8 TFW message to Seventh Air Force on 6 March: [92/]

> . . . rounds are wasted by continual firing at the target in an attempt to get a direct hit or produce a blower or burner. . . . Another factor to consider

> is that the combat environment does not usually permit prolonged firing orbit around the same target. We must maximize destruction damage in minimum time, then move on to avoid accurate AAA reaction.

The PAVE AEGIS crews felt that BDA reports actually were on the conservative side. Major John W. Hudson, a PAVE AEGIS pilot, stated:[93]

> I feel that the results of the 105 have been very satisfactory but I doubt that we can fully validate the true results. By this I mean, on the trail, truck killing cannot be adequately proven unless there is a "burner." In my own mind there were many more destroyed [trucks] than could be claimed.

The 105mm truck BDA question was not fully resolved until the summer of 1972, when CINCPACAF finally agreed that a truck which sustains a direct hit by 105mm HE/HEP ordnance should be scored as destroyed whether it burned or not.[94]

The question of tank BDA was still not resolved. The unique characteristics of the HEP round made it difficult to determine when a tank was destroyed since the HEP round does not pierce the armor plating on a tank, but impacts and is then set off by the fuse; the resulting explosion can destroy all hydraulic lines and knock loose innumerable bolts and much equipment. At the present time, the U.S. Army BDA criterion is being used. It states that a tank which can no longer fire or move is destroyed.[95]

CHAPTER VII

PROBLEMS OF THE PAVE AEGIS SYSTEM

Any system which develops from concept to combat as quickly as the PAVE AEGIS program and involves the Army, Navy, Air Force, and five major air commands and staff levels, from the Secretary of the Air Force to the squadron, is bound to encounter some problems. It is a major achievement that so few incidents occurred and that these were quickly and promptly rectified or identified for correction.

The elaborate fire control system was beset with numerous minor problems, the majority of which were traced to "fair wear and tear" and the stress put on the system by the combat environment. These problems normally affected system accuracy, and were consequently identified and corrected by maintenance personnel. As the rainy season set in, equipment deterioration was also blamed on the extremely wet climate.

The APQ-150 Beacon Tracking Radar which had been located in the rear troop door had to be removed to install the PAVE AEGIS system. This unit was used to detect, acquire, and track "I" band beacons used by friendly ground troops, and it provided target offset information from a given ground reference point. The 16 SOS identified the loss of the APQ-150 capability as one of the main disadvantages of the PAVE AEGIS system. By May, AFSC was working on the problem and had told CSAF: "We concur that the APQ-150 capability must be preserved. . . ."[96/] The initial fix, that of collocating the APQ-150 and ASD 5 Black Crow on a common

antenna, proved unfeasible. Later, the antenna was to be positioned near the rear door in the area vacated by the 40mm guns. Thus, the APQ-150 would again be available in all PAVE AEGIS aircraft.[97/]

The identification, modification, and use of the 105mm ammunition posed a number of serious problems. Well in advance of the CONUS tests of the 105mm gun, PACAF had inquired about available ammunition and requested assurance of full compliance with all safety factors.[98/] On 24 November, AFSC informed PACAF that they had assured a desired mix of 80 percent HE, 10 percent anti-tank, 9 percent WP, and 1 percent training rounds, and stated that Air Staff/PACAF assistance would be needed to secure an estimated 3,000 rounds per month. AFSC went on to say, "It is assumed that sufficient quantities exist in Army stockpiles to meet these requirements. . . . Safety problems are considered to be minimal since the gun and ammo are standard Army items in general use."[99/]

When the PAVE AEGIS Program Plan was published, the use of the anti-tank round had been specifically excluded due to safety and availability problems.[100/] This resulted in a diminished capability against tanks during the NVA invasion in April. The CONUS test evaluated only the 105mm HE and WP round.[101/] When the ammo was shipped to Ubon, problems immediately arose with the semi-fixed projectile of the 105mm ammunition. PACAF and its subordinate commands had been alerted to the fact that all rounds would have to be hand crimped. The projectile fit tightly enough into the shell for field artillery use, but with the barrel depressed below horizontal

for firing from the aircraft, there was danger of the projectile slipping out of the shell. The crimping, of itself, should have been no problem, although it was a time consuming operation (15 manhours/100 rounds).[102/] Of the three crimpers originally provided, however, only one of the mechanical crimpers was serviceable. The other was so badly corroded it could not be used, and the hand crimper, a reworked pipe cutter, proved worthless as a backup.[103/] Personnel of the 16 SOS were forced to modify and repair the crimpers continually: the hinges had to be replaced with stronger, locally fabricated ones; base plates were strengthened and enlarged; and stronger springs and fastening pins were added. The required rubber pads, a very short-lived item, could not be locally procured, and CONUS replacements had still not arrived as this report was finalized.[104/]

AFSC's 24 November message that "assured" the existence of sufficient quantities of ammo turned out to be overly optimistic. While the HE ammo was suitable, the WP caused problems. WP had been identified in testing as excellent for starting fires, marking targets, and destroying troops.[105/] Unfortunately, the WP ammo was delivered only in casings made of spiral wrapped steel which, it turned out, could not be crimped. When the crimping band was applied and tightened, the casing buckled or split.[106/] Once again, munitions personnel attempted on-the-spot modifications. A slow-setting glue was tested but was unsuccessful. Epoxy glue obtained from the Base Hobby Shop was also unsatisfactory. The spiral shell casing could not be used.[107/]

Action was promptly initiated to obtain brass casings. In a 14 April message to COMUSMACV citing combat essential operations, the 8 TFW identified (by Federal Stock Number) those WP rounds not suitable for the mission due to the casing, and asked for a trade. They closed their message by reiterating that the request was to support combat essential operations.[108/]

Five days later, a Seventh Air Force (ASD O/L) message to the 8 TFW stated in part, "In talks with 16 SOS and ASD PAVE AEGIS personnel, we understand that the WP rounds presently on hand are unacceptable for use." The message went on to ask that all problems be documented--why the rounds couldn't be used and why this hindered operations. It concluded by saying, "We are presently trying to obtain rounds from ARVN stockpiles. The coordination and political problems we are having should be apparent."[109/]

On 27 April 1972, the 8 TFW replied to all questions and sent the information directly to Seventh Air Force (DO/LG/DAFSC).[110/] In May, suitable WP ammo had been identified, sent to Ubon, and immediately placed in use. A minor problem of identification developed (since all shells had solid casings and looked identical) but was quickly resolved by the munitions people and aircrews.[111/]

Concurrent with efforts to resolve the WP problem, 8 TFW requested procurement of a more powerful antitank round to be used against tanks and heavy armor. ASD notified PACAF that the best available ammo was the M327 HEP round, but this round had not been formally certified for use in aircraft by the Non Nuclear Munitions Study Group (NNMSG). Due to the urgency of

the combat situation, a waiver was requested.[112] The NNMSG, in a lengthy reply that discussed the fully tested 20mm and 40mm ammo, answered the 105mm waiver request in this manner:[113]

> . . . It is the perogative of the operational commander to authorize the use of the M327 (HEP) ammo if he deems the actual situation is such that the use of the ammo is warranted. . . . The operational commander will have to make the decision. . . .

As this round was the only one which could effectively damage or destroy a tank, Seventh Air Force authorized a test of the HEP M327 round, and subsequently approved it but limited its use to tactical emergency situations only.[114] Although it proved to be an effective round, it too experienced problems. When the HEP M327 arrived, the steel casings were so thick that the mechanical crimper could not be used and a specially constructed hand crimper was used.[115]

By July 1972, it appeared that the major problems with the 105mm ammo had been identified and resolved. Action had been taken in March 1972 to procure factory-crimped ammo, but it probably would not be available for several months.

One final problem which affected not only the PAVE AEGIS aircraft but all AC-130s was engine performance. The PAVE AEGIS aircraft weighed more than other Spectres. Seventh Air Force stated in a message to PACAF:[116]

> The performance of the AC-130E is hampered with increased altitude because of heavier gross weight versus power available. Several breaks to avoid antiaircraft fire have been known to produce the characteristic bubble [sic] prior to a stall.

On 7 June 1972, the 8 TFW submitted a proposed Combat ROC: "T56A-15 Engine for AC-130E Gunships." This Required Operational Capability (ROC) pointed out that performance was marginal in the combat environment and identified the benefits to be gained from the installation of a more powerful engine.[117/]

The PAVE SPECTRE Conference on 6 and 7 June 1972 addressed the problem and recommended that the installation of a more powerful engine begin in September 1972. The new engine would provide 25 percent more thrust horsepower in flight and 20 percent more torque for takeoff. It would provide the additional power required during the critical periods encountered at takeoff and during combat.[118/]

CHAPTER VIII

CONCLUSION

The initial PAVE AEGIS program plan called for combat evaluation of the system during Commando Hunt VII, but the North Vietnamese invasion put the system to its most severe test. In all situations, whether employed against trucks, tanks, armor, PATs, or in TIC situations, the PAVE AEGIS acquitted itself with distinction, as verified BDA attested. Reported statistics alone, however, do not demonstrate the total effectiveness, especially in TIC situations. For instance, on 6 May, Spectre 03, a PAVE AEGIS aircraft, was diverted to work a TIC situation near Polei Kleng in MR II. All U.S. personnel had been evacuated, so the crew worked directly with the ARVN commander. The crew's mission report reflected that all 105mm ammo was expended (96 rounds), and BDA was one large secondary explosion, one bridge set afire, and some mortars silenced. The full story of this remarkable mission did not emerge until the Worldwide Gunship Conference in June. In assessing gunship capabilities, Defense Intelligence Agency records revealed that Spectre 03 was credited with killing over 350 enemy soldiers, repulsing a full-scale attack by an enemy regiment, and saving over 1,000 friendly lives.[119/] Perhaps Major J. W. Hudson, a PAVE AEGIS pilot, had the right solution for determining PAVE AEGIS effectiveness in a TIC situation when he said:[120/]

> If I were on the ground under attack and the assault was broken, I would be most happy and feel the effectiveness of the weapon used was 100 percent.

A true measure of success was the notation on a mission report, "Situation quiet upon departure."[121/]

Ground commanders enthusiastically acclaimed the PAVE AEGIS system, and employed it efficiently in a variety of situations. As noted earlier in this report, their first question to a Spectre gunship was, "Do you have the big gun?" It was obvious to the crews that commanders really wanted the 105mm howitzer. As Major K. A. Ingram, USA, an An Loc veteran, said, "The . . . [PAVE AEGIS] is the most valuable weapon in the Air Force arsenal."[122/]

Air Force message traffic indicated the growing esteem of PAVE AEGIS. "Results as advertised," "This tremendously effective weapon," "PAVE AEGIS is a flexible and versatile weapon system. . . ." "We recommend installation of 105mm gun on all AC-130Es."[123/]

The PAVE AEGIS system provides the Army and the Air Force with an airborne artillery system that is fantastically accurate and introduces a full range of firepower which can be applied selectively as the mission and target dictate.

The success of the weapon system is best reflected by the fact that less than four months after employment, all AC-130E gunships had been approved for the PAVE AEGIS modification.[124/]

APPENDIX I

AC-130E SYSTEM CONFIGURATION LIST

Fire Control System

Fire Control System Power Supply, PP-6827

Boresight Adjust Panel

Fire Control/Navigation Computer Set, AN/ASN-91

Fire Control System Display Set, AV/AVQ-21

Fire Control System Air Data Measurement System

Inertial Measuring System AN/ASN-90

Teleprinter, Thermochrome, TT-521/ARC-96

Three Axis Gyro, A24G-1A

Wing Boom Static System

Sensors

Search Radar APN-59B MTI Mod

Beacon Tracking Radar, AN/APQ-150

Stabilized Tracking Set, AN/AJQ-24A

Video Recorder, AN/AXH-2

B.C. Ignition Detection Sensor, AN/ASD-5

Low Light Level Television Syst, AN/ASQ-145/GLINT

Video Switching System, AXQ-10

Forward Looking Infrared Sensor System AN/AAD-7

IR Fairing

Gun System

7.62MM Gun Systems, GAU-2B/A (2 ea) (Not operationally installed)

20MM Gun Systems, M-61 (2 ea)

40MM Gun Systems (1 ea)

105MM Gun Systems (1 ea)

Illuminators

Platform Assembly, LAU-74A

Searchlight Set AN/AVQ-17

Laser Target Designator/Ranger, AN/AVQ-19

Interface Items

Sensor Light Angle Display System (SLADS)

Slave Switching Unit

Switching Unit Control

Control, Searchlight Alignment Unit, C-9205/A

Survivability

Hydraulic Switching Valve

Emergency Egress System

Ceramic Armor

Ballistic Curtains

Armored Seats

Communication/Navigation

Loran Navigation Set, AN/ARN-92

Radio Set, AN/ARC-133

X-Band Beacon, SST-181X

Intercommunications Set AN/AIC-18 (12 A/C)

Radio Set, FM-622 (2 A/C)

Secure Radio KY-28

ECM

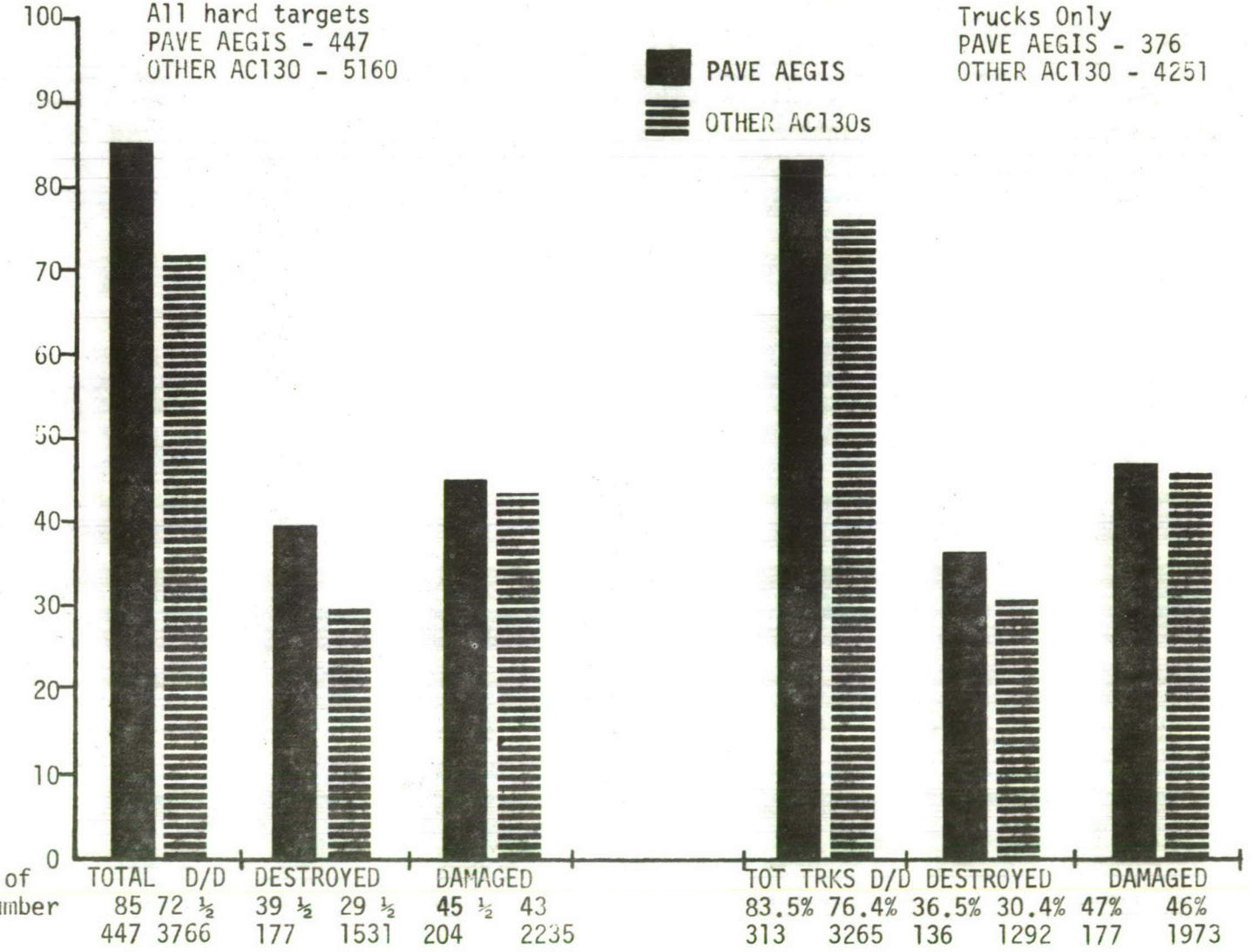
Radar Receivers, AN/APR 36/37

ECM Set AN/ALQ-87 Modified

Deceptive Repeater System, Trim-7A

APPENDIX II

DESTRUCTIVE EFFECT ON OBSERVED TARGETS (24 FEB–30 JUN 72)

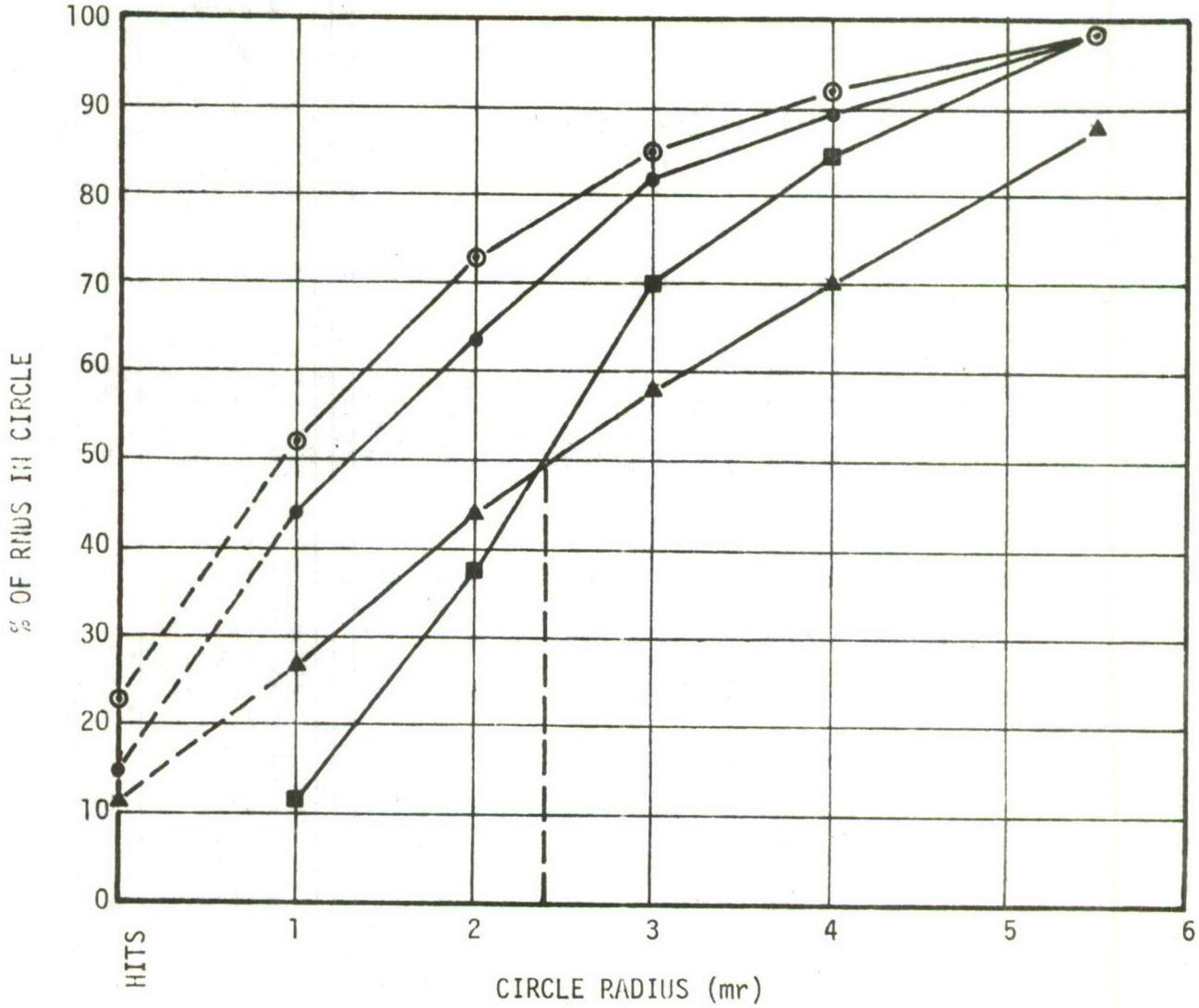


Statistical Base obtained from SEADAB file, MACV Strike computer, MACDO-24

[redacted]

APPENDIX III

ACCURACY COMPARISON DATA CHART



[redacted]

FOOTNOTES

1. Project CHECO Southeast Asia Report (S), First Test and Combat Use of the FC-47, p. 1.

2. Project CHECO Southeast Asia Report (S), The Role of USAF Gunships in SEAsia, 30 Aug 69, pp. 2-3. (Hereafter cited as CHECO, USAF Gunships).

3. Ibid., p. 3 ff.

4. Ibid., p. 26.

5. Project CHECO Southeast Asia Report (S), Fixed Wing Gunships in SEA (Jul 69-Jul 71), 30 Nov 71, p. 28 ff. (Hereafter cited as CHECO, Fixed Wing Gunships).

6. Ibid., Chapter IV.

7. COMMANDO HUNT III (Headquarters Seventh Air Force), May 1970, p. XVII (S). (Hereafter cited as Commando Hunt III).

8. CHECO Report (S), Fixed Wing Gunships, p. 103.

9. COMMANDO HUNT VII (Headquarters Seventh Air Force), June 1972, pp. 256-257 (S). (Hereafter cited as Commando Hunt VII).

10. Commando Hunt III, pp. 186-187 (S); Commando Hunt VII, pp. 258-259 (S).

11. PAVE AEGIS Program Plan (S), 2 Dec 1972, p. 1-1. (Hereafter cited as PAVE AEGIS Plan).

12. Aeronautical Systems Division, Flight Test Plan/Report XR 71-8-11, 10 Sep 71, p. 2 (U). (Hereafter cited as Flight Test Plan/Report).

13. Ibid., p. 8.

14. Msg (U), 4950 ENEO WPAFB, Ohio to CSAF/RDQ, PACAF, 7AF, et. al., 231941Z Sep 71, subj: Large Caliber Gun, Phase II Flash Summary Report of Gunship Firing Flight Tests.

15. PAVE AEGIS Plan, p. 1-1 (S).

16. Staff Summary Sheet (U), 7AF/DOXQ to 7AF/DO, subj: PAVE AEGIS Deployment to SEA, 22 Dec 71. (Hereafter cited as Staff Summary, 22 Dec 71.)

17. Msg (S), CINCPACAF to ASD WPAFB, Ohio, subj: AC-130 with 105mm Cannon (C), 100332Z Nov 71.

18. Msg (S), CINCPACAF to CSAF, info ASD; subj: 105mm Cannon for the AC-130E, 102143Z Nov 71.

19. Msg (S), CINCPACAF to ASD WPAFB, Ohio, subj: AC-130E with 105mm Cannon, 192136Z Nov 71. (Hereafter cited as CINCPACAF 192136Z).

20. PAVE AEGIS Plan, pp. 1-1, 1-2 (S).

21. Ibid., p. 2-1 (S).

22. Msg (S), AFSC to CINCPACAF/DOQ/DO, subj: AC-130E with 105mm Cannon (C), 241452Z Nov 71. (Hereafter cited as Msg AFSC 241452Z Nov 71).

23. PAVE AEGIS Plan (S).

24. Msg (S), 7AF to CINCPACAF, subj: 105 Cannon for AC-130E, 100915Z Dec 71.

25. Staff Summary, 22 Dec 71 (U).

26. Msg (S), 7AF to CINCPACAF/DO/DOQ, subj: PAVE AEGIS, 201748Z Dec 71.

27. PAVE AEGIS Plan, pp. i, ii (S).

28. Msg (S), Hq ASD WPAFB, Ohio to CSAF, info to CINCPACAF, 7AF, et. al., subj: PAVE AEGIS Test, 112112Z Feb 72. (Hereafter cited as Hq ASD 142112Z Feb 72).

29. PAVE AEGIS Plan, p. 3-1 (S).

30. Hq Aeronautical Systems Division/SDY, PAVE Spectre Conference, 6-7 June 72, p. 2-15 (S). (Hereafter cited as PAVE Spectre Conference). PAVE AEGIS Plan, Sect's III, IV, VI (S).

31. Msg (S), 8TFW to CSAF, subj: PAVE AEGIS Weekly Activity Report Number 1, 021605Z Mar 72. (Hereafter cited as Msg 8TFW 021605Z Mar 72).

32. Memo for Record, Chief, Gunship Branch [16SOS] to DO [16SOS], subj: PAVE AEGIS Status, Undated (S). (Hereafter cited as MR Gunship Branch).

33. Rpt (S), 16SOS Mission Reports AC-130E, Feb-Jul 1972, Ubon RTAFB, by Aircraft Commanders. (Hereafter cited as Mission Reports).

34. Msg (S), ASD WPAFB, Ohio to CINCPACAF/DO, subj: PAVE AEGIS (U), 021350Z Mar 72.

35. Msg (S), 7AF to 8TFW, subj: PAVE AEGIS, 130430Z Mar 72.

36. Msg (S), 8TFW Ubon RTAFB, Thailand to 7AF/DOX and PACAF/DOQ, subj: PAVE AEGIS 75 Day Report (U), 230815Z May 72. (Hereafter cited as PAVE AEGIS 75 Day Report).

37. Msg (S), 8TFW to 7AF/DO, subj: PAVE AEGIS (U), 161616Z Mar 72.

38. Msg (S), 7AF/DO to 7/13AF and OUSAIRA VTN, Laos, subj: Request for AC-130 Support, 211105Z Mar 72. (Hereafter cited as 7AF/DO 211105Z Mar 72.

39. Msg (S), 8TFW/DOGB Ubon RTAFB, Thailand to CSAF, subj: PAVE AEGIS Weekly Report, 211500Z Mar 72. (Hereafter cited as 8TFW/DOGB 211500Z Mar 72).

40. Msg (S), PAVE AEGIS 75 Day Report.

41. History (S), 16SOS, Ubon RTAFB, Thailand, 1 Jan-31 Mar 72. (Hereafter cited as Hist 16SOS, Jan-Mar 72).

42. Intvw (S), Lt Col R. R. Kelsay, 16SOS Staff Officer and PAVE AEGIS pilot by Maj J. C. Thomas, 5 Jul 72. (Hereafter cited as Kelsay Interview).

43. PAVE AEGIS Plan, p. 1-2 (S).

44. Msg (S), AFATL Eglin AFB to AFSC, subj: Improved Anti-Armor Capability for 105mm Howitzer M-137, 271325Z Apr 72.

45. Msg (S), 7AF/DO to 8TFW, subj: 105mm, M327 HEP Round, 181200Z May 72. (Hereafter cited as 7AF/DO 181200Z May 72).

46. Msg (S), 8TFW/DOGB to CSAF, subj: PAVE AEGIS Weekly Report, 190845Z Apr 72.

47. Msg (S), 7AF/DO to CINCPACAF, subj: PAVE AEGIS, 240145Z Apr 72.

48. Intvw (S), Capt W. O. Fulk, Chief Gunship Branch, 7/13AF Directorate of Operations with Maj J. C. Thomas, 11 Jul 72. (Hereafter cited as Fulk Interview).

49. Hist (S), 16SOS Ubon RTAFB, 1 Apr-30 Jun 72, pp. 45-46. (Hereafter cited as Hist 16SOS Apr-Jun 72).

50. Hist (S), 16SOS, Jan-Mar 72.

51. Hist (S), 16SOS, Apr-Jun, p. 56.

52. Kelsay Interview (S).

53. Project CHECO Southeast Asia Report (S), The Battle for An Loc, 5 Apr-26 June 1972, p. 70.

54. Kelsay Interview (S).

55. After Action Report (S), Binh Long Campaign, 20 Jun 72 by Col W. F. Ulmer, Jr. (MACTR-5). (Hereafter cited as Ulmer After Action Report).

56. STARS AND STRIPES, 2 Jun 72, p. 2 (U).

57. Ulmer, After Action Report, p. 17 (S).

58. Project CHECO Southeast Asia Report (S), KONTUM: Battle for the Central Highlands 30 Mar-10 Jun 72, pp. 75-76.

59. Hist (S), 16SOS Apr-Jun 72, p. 16.

60. Msg (S), AFSC 241452Z Nov 71.

61. PAVE AEGIS Plan, p. 6-2 (S).

62. Msg (S), 7AF to CINCPACAF/DO/DOQ, subj: PAVE AEGIS, 261748Z Dec 71. (Hereafter cited as 7AF 261748Z Dec 71).

63. MR Gunship Branch (S).

64. Intvw (S), Col J. E. Davis, Commander 16SOS, with Maj J. C. Thomas, 8 Jul 72.

65. Hist (S), 16SOS, Jan-Mar 72, p. 51.

66. Msg (S), 8TFW 021605Z Mar 72.

67. Msg (S), ASD/SDY WPAFB, Ohio to CINCPACAF, subj: PAVE AEGIS BDA Criteria, 082220Z Mar 72; Msg (S), 7AF to CINCPACAF/DO, subj: Gunship Configuration, 080205Z Apr 72. (Hereafter cited as 7AF 080205Z Apr 72).

68. Fulk Interview (S).

69. Msg (S), CINCPACAF to 7AF/DO, subj: Gunship Losses, 252010Z Mar 72.

70. Msg (S), 8TFW to 7AF, subj: Gunship Armament, 301200Z Mar 72. (Hereafter cited as 8TFW, 201200Z Mar 72).

71. Msg (S), 7AF to CINCPACAF/DO, subj: Gunship Losses, 030150Z Apr 72. (Hereafter cited as 7AF 030150Z Apr 72).

72. Kelsay Interview (S).

73. Ibid.

74. Msg (S), 7AF 030150Z Apr 72.

75. Msg (S), Hq ASD 142112Z Feb 72.

76. Intvw (S), Lt Col E. Bauman, AFSC Liaison Officer from AFA with Maj J. C. Thomas, 26 Jun 72.

77. Intvw (S), Lt Col T. F. Debnam, 16SOS PAVE AEGIS Project Officer with Maj J. C. Thomas, 8 Jul 72.

78. Air Force Academy (S), PAVE AEGIS Test Report and AC-130E Fire Control Data Analysis (unpublished).

79. Fulk Interview (S).

80. Msg (S), 8TFW 230815Z May 72.

81. Ibid.

82. Intvw (S), Capt J. W. Strickler, PAVE AEGIS Aircraft Commander by Maj J. C. Thomas, 3 Jul 72.

Commando Hunt V (Headquarters Seventh Air Force), p. 265 (S).

83. Fulk Interview (S); Kelsay Interview (S).

84. Commando Hunt V, pp. 55-57 (S): CHECO, Fixed Wing Gunships, pp. 55-60 (S).

85. Mission Reports (S).

86. Msg (S), 8TFW to 7AF/DO, subj: PAVE AEGIS BDA Criteria, 060400Z Mar 72. (Hereafter cited as 8TFW 060400Z Mar 72).

87. Msg (S), CSAF/XOO/RDP to CINCPACAF, subj: PAVE AEGIS Reporting and BDA Criteria, 072136Z Mar 72.

88. Msg (S), ASD/SDY WPAFB, Ohio to CINCPACAF, subj: PAVE AEGIS BDA Criteria, 082220Z Mar 72.

89. PAVE AEGIS Plan, p. 1-2 (S).

90. Msg (S), CINCPACAF/DO to 7AF, subj: PAVE AEGIS BDA Criteria 100330Z Mar 72.

91. Msg (S), 7AF/DO/DOX to 8TFW, subj: PAVE AEGIS BDA Criteria 142315Z Mar 72.

92. Msg (S), 8TFW 060400Z Mar 72.

93. Intvw (S), Maj J. W. Hudson, 16SOS Executive Officer by Maj J. C. Thomas, 6 Jul 72.

94. Msg (S), CINCPACAF/DO to 7AF, subj: PAVE AEGIS BDA Criteria, 190230Z Jul 72.

95. Hist (S), 8TFW, Ubon RTAFB, Apr-Jun 1972, p. 19. (Hereafter cited as Hist 8TFW Apr-Jun 72).

96. PAVE AEGIS Plan, p. 4-2 (S).

97. PAVE Spectre Conference, p. 2-15. (S).

98. Msg (S), CINCPACAF 190136Z Nov 71.

99. Msg (S), AFSC 241452Z Nov 71.

100. PAVE AEGIS Plan, p. 1-2 (S).

101. Ibid.

102. Msg (S), AFSC 241452Z Nov 71; Hist (S), 8TFW, Ubon RTAFB Jan-Mar 1972, p. 54. (Hereafter cited as Hist 8TFW Jan-Mar 72).

103. Ibid., p. 52-53.

104. Hist (S), 8TFW Apr-Jun 72, p. 59.

105. Msg (S), 8TFW to 7AF/DO/LG/DAFSC, subj: PAVE AEGIS (U), 271202Z Apr 72. (Hereafter cited as 8TFW 271202Z Apr 72).

106. Ibid.

107. Hist (S), 8TFW Jan-Mar 72, p. 53.

108. Msg (S), 8TFW to COMUSMACV/Attn: MACJ 42, subj: 105mm WP Ammo, 141025Z Apr 72.

109. Msg (S), 7AF ASD O/L to 8TFW, subj: PAVE AEGIS Munition Requirement, 190535Z Apr 72.

110. Msg (S), 8TFW 271202Z Apr 72.

111. Hist (S), 8TFW Apr-Jun 72, p. 53.

112. Msg (S), 8TFW/DOEC to ASD WPAFB, subj: PAVE AEGIS, 261120Z Apr 72.

113. Msg (S), ASD WPAFB, Ohio to CINCPACAF/DO/LG, subj: PAVE AEGIS (U), 281628Z Apr 72.

114. Msg (S), 7AF/DO 181200Z May 72.

115. Hist (S), 8TFW Apr-Jun 72, p. 59.

116. Msg (S), 7AF 030150Z Apr 72.

117. PAVE Spectre Conference, Atch 9 (S).

118. PAVE Spectre Conference, p. 9-13; Atch 9 (S).

119. Hist (S), 16SOS, Apr-Jun 72, pp. 50-51.

120. Hudson Interview (S).

121. Hist (S), 16SOS, Apr-Jun 72, p. 51.

122. STARS AND STRIPES, 2 Jun 72, p. 2 (U).

123. Msg (S), 8TFW/DOGB 211500Z Mar 72; 7AF/DO 211105Z Mar 72; 8TFW 301200Z Mar 72; 7AF 080205Z Apr 72.

124. PAVE Spectre Conference (S).

GLOSSARY

AAA	Antiaircraft Artillery
AFCS	Air Force Systems Command
AGL	Above-Ground Level
Ammo	Ammunition
Armed recce	Armed reconnaissance
ASD	Aeronautical Systems Division
BDA	Battle Damage Assessment
BLACK CROW	(S) An ignition system detection sensor (BC)
CEP	Circular error probable, an indicator of the accuracy of munitions delivery, used as a factor in determining probable damage to a target. It is the radius of a circle within which half of all munitions expended is expected to fall.
CHECO	Contemporary Historical Examination of Current Operations
CINCPAC	Commander-in-Chief, Pacific Command
CINCPACAF	Commander-in-Chief, Pacific Air Forces
CIP	Computed Impact Point by electronic sensors
Commando Hunt I, III, V, VII	(S) Air interdiction of the overland flow of supplies from NVN to VC and NVN forces in South Vietnam and Cambodia. These campaigns in southern Laos (Steel Tiger area of operations) bore numerical designations that changed with the semi-annual monsoonal shift. The four northeast-moonson, or dry season campaigns, took place in 1968/1969, 1969/1970, 1970/1971, and 1971/1972, and covered roughly the period from October through April.
CONUS	Continental United States
d/d	destroyed/damaged
DMZ	Demilitarized Zone
FAC	Forward Air Controller
FCS	Fire Control System
fps	Feet Per Second
GLINT	Gated Laser Intensified Night Television
HE	High Explosive
HEAT	An antitank 105mm round
HEP	High Explosive Plastic, an antitank 105mm round
HEP-T	High Explosive Plastic, Tracer
Hq	Headquarters

LGB	Laser Guided Bomb
LLLTV	Low Light Level Television
LOC	Line(s) of Communication
mil	milliradian, angular measurement
NNMSG	Non Nuclear Munitions Study Group
NVN	North Vietnam(ese)
PAT	Perishable Area Target
PAVE AEGIS	(S) Code name for 105mm weapon system on AC-130E Gunship
PAVE PRONTO	The acquisition of six additional AC-130A aircraft for SEA, plus additional gunship training aircraft.
PAVE SPECTRE	The acquisition of AC-130E gunships
POL	Petroleum, Oil, and Lubricants
rds	Round(s)
RNO	Results not observed
ROC	Required Operational Capability
RTAFB	Royal Thai Air Force Base
RVN	Republic of Vietnam
SA-7	Heat seeking surface-to-air missile-Strela
SAR	Search and Rescue
SEA	Southeast Asia
16SOS	16th Special Operations Squadron at Ubon, Thailand
SURPRISE PACKAGE	(S) An enhanced AC-130A gunship aircraft with improved offensive and survival capabilities due to the addition of special Aeronautical Systems Division equipment. The aircraft became a combat test bed for improved techniques and equipment.
8TFW	Eighth Tactical Fighter Wing at Ubon RTAFB, Thailand
TIC	Troops in Contact
TOT	Time on Target
TV	Television
VC	Viet Cong
WP	White Phosphorus